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***Fact Sheet 98-49***

# Alfalfa Irrigation Scheduling with an Automated Evaporation Pan System

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## Introduction

Nevada is the most arid state in the nation. Virtually all crop production in Nevada is dependent upon irrigation to maintain economically viable yields. As a result, agriculture uses approximately 83% of all water consumed in the State according to the "1992 Nevada Water Facts" publication by the Division of Water Planning. The amount of water needed by the state in the future is projected to rapidly increase because Nevada has the fastest growing population rate in the nation. Unfortunately, the water supply will not increase in response to growing demand. This means agriculture will need to be more efficient in its use of water. Otherwise, maintaining the current situation will only increase the intensity and scope of the current "water wars" which are raging over agricultural water use in Nevada.

## Irrigation Scheduling

The purpose of irrigation is to provide the optimum quantity of water needed by growing plants at the correct time to produce maximum economic yields. Benefits of proper irrigation scheduling are:

- reduced water application;
- reduced percolation losses;
- reduced energy costs;
- reduced runoff; and
- improved crop quality.

Water applied at the wrong time and in too large a quantity is wasted. It can run off the end of a field or can percolate beneath the root zone making it unavailable for crop use. When insufficient amounts of water are applied to a growing crop it is stressed, resulting in less than optimum transpiration rates and ultimately yield reductions. Research by Guitjens (1987) and Staubitz (1978) has shown that evapotranspiration (ET) is highly correlated with yield and that deficit irrigation should be avoided to maximize production. Various irrigation scheduling methods are available to help producers apply the correct amount of water at the correct time.

Two important components of irrigation scheduling are determination of ET and selection of an irrigation scheduling method. ET is defined as the combined amounts of transpiration from plants, and evaporation from plant and bare soil surfaces. It is dependent upon climatic conditions as well as crop growth stage. The amount of water used by crop ET must be replaced by irrigation to sustain crop growth. ET can be estimated through the use of devices such as weather stations or evaporation pans. The method chosen to estimate ET may dictate the selection of an irrigation scheduling method. There are equations such as Penman's, or methods such as the water budget that can be used for irrigation scheduling. ET data allows the producer to schedule irrigation knowing the amount of water the crop needs.

Recently, precision agriculture technologies have made significant advances in the area of irrigation scheduling and soil moisture determination. Equipment for continuous monitoring of soil moisture and climatic conditions is now available to help producers determine how much water to apply and when to apply it. Most literature recommends irrigating alfalfa when fifty percent of the available moisture in the soil profile has been depleted by the growing crop. Depletion beyond this point can stress the crop resulting in less than optimum production. Producers can determine the amount of available water their soil will hold with the help of the Natural Resource Conservation Service. Then, with precision agriculture equipment the producer can monitor the soil profile and climate and with the use of irrigation scheduling apply only enough water to refill the soil profile to the desired depth.

In many areas of Nevada where alfalfa is currently being grown, irrigation is commonly scheduled based on factors other than crop needs. For example, a producer may use wheel lines and irrigate each section of a field using a 14 day return time because of irrigation system design. The system has limited flexibility if ET dictates a crop watering regime different from the original system design. Another example is when a producer drills a well and installs a center pivot. In cases where the quantity of water available for the pivot acreage is insufficient, the system may need to run constantly and still may not meet the ET requirements of the crop. This Fact Sheet describes a project to schedule irrigation based on crop, soil, and environmental factors to make more efficient use of our limited water resources.

**Irrigation**

Phene (1992) and Phene (1995) showed that frequent measurement of evaporation rates from an automated Class A evaporation pan corrected for water density and pan deformation errors can accurately estimate ET and be used as an irrigation scheduling tool. Key to Phene's work is the finding that ET data is more accurate when the water level in the pan is measured hourly and the pan is refilled daily to a preset reference level to maintain a nearly constant thermal mass of water. Irrigation is then scheduled with this system by multiplying the pan evaporation value (Epan) by a crop coefficient (Kc). Crop coefficient values vary and are based on geographic location and crop growth stage.

In 1996 Phene, et.al. conducted a study where several fully automated Class A evaporation pan configurations and a weather station were compared to a precision weighing lysimeter (assumed to be the standard) which was planted to a cool season grass to determine reference ET (ETo). Results showed that 0.9 multiplied by the ET values from a Class A pan covered with a 50 millimeter wire screen most closely correlate to the ETo measurement of the lysimeter.

**Reese Valley Project**

In October 1997 a fully automated Class A evaporation pan system using an electronic level sensor and data acquisition system was installed in Reese Valley, Nevada on a center pivot irrigating alfalfa. The major components of the system and their functions are:

- Class A evaporation pan - evaporation rates are measured hourly, the pan is automatically refilled to a preset threshold level every day at 12:00 A.M.;
- electronic fluid level sensor - senses the water level in the pan;
- anemometer - measures wind speed;
- tipping bucket rain gauge - measures rainfall;
- soil moisture and temperature sensors at two locations in the field - at each location a sensor was placed at 12 and 30 inches in depth, soil temperature and moisture

data is collected hourly;
- datalogger - all collected data is stored in a datalogger prior to downloading to a computer;
- cellular telephone and antenna - data is transferred from the project site to any location by computer and modem.

Data from the instruments is collected once each hour and stored in the datalogger. The data can be downloaded through the use of a computer connected by modem to the cellular telephone at the project site. Figures 1 and 2 show a partial printout of the data once it has been downloaded and put into useable form. Data shown are from August 25, 1998. Following is an explanation of the pertinent irrigation information in Figures 1 and 2:

**Figure 1. Evaporation Pan and Evapotranspiration Data**

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Date | Day of Year | Pan Fill (in) | $K_c$ | |
| | | 8/25/98 | 237 | 0.264 | 0.26 | |
| Hour | Ref. Level (in) | $E_{pan}$ (in) | $ET_c$ (in) | Residual (in) | Wind (mph) | Max. Wind (mph) |
| 100 | 0.920 | 0.000 | 0.000 | 0.00 | 3.61 | 5.07 |
| 200 | 0.918 | 0.002 | 0.001 | 0.00 | 2.08 | 5.26 |
| 300 | 0.914 | 0.004 | 0.001 | 0.00 | 3.44 | 5.74 |
| 400 | 0.910 | 0.004 | 0.001 | 0.00 | 1.76 | 4.84 |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| 2400 | 0.659 | 0.012 | 0.003 | 0.08 | 3.87 | 6.32 |
| | | Total $E_{pan}$ (in) | Total $ET_c$ (in) | | Ave. Wind (mph) | Max. Wind. (mph) |
| Daily | | 0.259 | 0.067 | | 3.38 | 15.38 |

**Figure 1.**

- Date and Day of Year: Date the report was printed out and the number of the day in the year.
- Pan Fill: Amount of water (inches) added to the pan at 12:00 A.M. the previous day.
- Kc: Calculated crop coefficient used in the ETc calculation.
- Hour: Time of day in military time.
- Ref. Level: Water level in the evaporation pan, used as a reference to the changes in water level (not the distance from the top or the bottom of the pan).
- Epan: Amount of evaporation from the pan during a particular hour time period. The difference between any two consecutive hour time periods in the Reference Level column is the amount of pan evaporation for that hour.

- ETc: Calculated ET rate for a particular hour time period (ETc = Epan * Kc).
- Residual: Running total of the hourly ETc values.
- Wind and Max Wind: Wind speed and maximum wind speed during a particular hour time period.
- Total Epan: Total evaporation amount from the pan in the last 24 hours.
- Total ETc: Calculated ET rate for the past 24 hours (Total ETc = Total Epan * Kc).
- Ave. Wind and Max Wind: Average wind speed and maximum wind speed during the past 24 hours.

**Figure 2. Soil Temperature and Moisture Data**

| | Date 8/25/98 | Day of Year 237 | Max. Batt. (volt) 13.90 | Min. Batt. (volt) 13.00 | Max. Temp. 94.8 | Min. Temp. 38.3 |
|---|---|---|---|---|---|---|
| Hour | Soil Temp. 12 inches(F) | Soil Temp. 30 inches(F) | Soil Matric Potential 12 inches (Bar) | Soil Matric Potential 30 inches (Bar) | Rain (in) | |
| 100 | 63.3 | 61.6 | -1.909 | -0.923 | 0.00 | |
| 200 | 63.2 | 61.6 | -1.909 | -0.926 | 0.00 | |
| 300 | 63.3 | 61.7 | -1.903 | -0.920 | 0.00 | |
| 400 | 63.2 | 61.7 | -1.906 | -0.923 | 0.00 | |
| . | . | . | . | . | . | |
| . | . | . | . | . | . | |
| 2400 | 63.5 | 61.4 | -1.896 | -0.907 | 0.00 | |
| | Soil Temp. 12 inches(F) | Soil Temp. 30 inches(F) | Soil Matric Potential 12 inches (Bar) | Soil Matric Potential 30 inches (Bar) | Rain (in) | |
| Daily Avg. | 62.8 | 61.7 | -1.910 | -0.923 | 0.00 | |

**Figure 2.**

- Max. Temp. and Min. Temp.: Maximum and Minimum temperature of the datalogger during the past 24 hours.
- Soil Temp.: Soil Temperature at the 12 and 30 inch depths during a particular hour, as well as the average soil temperature for the past 24 hours.
- Soil Matric Potential: Matric potential is an index of soil water. It represents the amount of energy with which water is held by the soil particles. Soil matric potential must be overcome by plants before they can extract soil water. Matric potential is measured in units of bars. Moisture retained in the soil between the ranges of 0.1 bar (field capacity) and 15 (permanent wilting point) is available for plant use. Matric potential values are negative since they represent suction as opposed to pressure.

Optimum matric potential values should not go much below -1.0 bars for optimum plant growth (Brady, 1984).

Figure 2 shows hourly matric potential values and average values for the past 24 hours at two depths in the soil.

- Rain: Rainfall amounts during the past hour, as well as 24 hour total.

Data from the evaporation pan site can be downloaded once each hour. In practice, data should be downloaded and reviewed at least once every two to three days.

**Practical Use of Printout Data**

As seen in Figure 1. the printout gives a daily Total ETc value in inches. ETc is the amount of water to apply for that day. However, few irrigation systems have the capability to apply water to an entire field on a daily basis. In reality, it will be several days or more at a minimum since the last time the field was irrigated. Therefore, these values must be summed for each day during a given time period and the total amount of water applied at the next irrigation. Figure 2. shows matric potential values for the same daily time period.

By reviewing matric potential values an irrigator can determine the moisture status of the soil and how it is being impacted by the precipitation rate of the irrigation system. Matric potential values consistently less than -1.0 indicate more water is needed to maintain the root zone in optimum condition for plant growth. Wind and temperature values are used as references to show how they effect ET rates.

During the first year of this trial, the automatic evaporation pan system will be used to monitor ET rates and the moisture condition of the trial field. At the conclusion of the production season, comparisons will be made between actual water applications to the field and the collected data. If the review indicates the producer needs to take some type of corrective action regarding water management, appropriate measures will be taken before the next production and monitoring season.

**Conclusion**

Irrigation scheduling has been shown to have many benefits. Precise determination of ET is available to agricultural producers to assist in irrigation scheduling. A precision irrigation scheduling system and trial has been set up in Reese Valley, Nevada to help producers address the issue of irrigation scheduling and irrigation water management. Contact the Lander County Cooperative Extension office for program updates or to schedule a tour.

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